ON THE

EFFECTS OF

RICKETS

UPON THE GROWTH OF THE SKULL.

By ALEXANDER SHAW, Esq.,

SURGEON TO THE MIDDLESEX HOSPITAL.

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Some years ago the Society did me the honour to publish in their Transactions, a paper on certain peculiarities in the conformation of the skeleton produced by rickets.* In that paper, my principal object was to show that, independently of the softening and consequent incurvation of the bones to which rickets has been long known to give rise, it has the effect of arresting the growth; and, as between infancy and adolescence, a remarkable change takes place in the relative proportions of the figure,

* Vol. xvii. The same subject was further pursued in two papers communicated by the author to the London Medical Gazette, March 1835, and Nov. 1835.

so that those of the adult differ widely from those of the child, the progress of that change is interrupted by the stoppage; and the result is, that persons so affected, when they arrive at adolescence, have the configuration characteristic of the child, more or less distinctly marked, instead of that proper to the adult.

Since presenting these views to the Society, my attention has been directed in a more particular manner than before, to the form of the head in individuals distorted from the same disease; and I have observed that there is in this part a want of the correct relative proportions between the two principal divisions of which it consists—the cranium, and the face—analogous to what is found in the body generally. As in prosecuting that inquiry, several questions, interesting both in a physiological and practical view, have presented themselves to my notice, I beg to lay my observations before the Society.

It being necessary for the illustration of my present subject, to point out more fully the effects produced upon the relative dimensions of the figure generally by rickets, I will briefly recapitulate some of the facts contained in my former paper.

The short stature of persons who have suffered during childhood from that disease has often been observed. But it may not have been so commonly remarked that, (making allowance for the loss of height caused by the greater or less incurvations of the bones in such individuals,) certain parts of the

figure are always stunted to a greater degree than others. The head, trunk, and upper extremities continue about their natural size; while the pelvis and lower extremities are peculiarly diminutive.

This peculiarity may be seen by looking at the shape of those persons deformed from rickets, who are met with in such numbers in the streets of this metropolis. But to verify my observation more accurately, I took the measurements of the bones in the upper and lower divisions of the body in several adult skeletons deformed from the disease; and compared them with corresponding measurements of the natural skeleton. The result was, that whereas the defect of growth in the superior division was equal only to $\frac{1}{13}$th of the whole, it was as much as $\frac{1}{3}$rd in the inferior division.

The cause of this difference may be thus explained. In the process of growth, all parts of the frame do not increase at the same rate. If such were the law of development, the proportions would be the same at adolescence as in childhood. But that is not the case. In the child, the upper part, including the head, trunk, and upper extremities, is of large bulk compared with the pelvis and lower extremities. But in the adult, the head, trunk, and upper extremities are particularly light and small, and the pelvis and lower extremities are broad and powerful. And important objects are attained by this difference in the conformation. The proportions in infancy have reference to parturition; the head is of large size compared with the rest of the body,

in order that, while the fœtus is floating in the liquor amnii, the head may gravitate to the os uteri, and by closing that orifice prevent the presentation of the hands or feet; and, secondly, that when delivery commences, and the head is expelled first, it may dilate the parts, and allow the hips to pass rapidly, so as to prevent the umbilical cord being compressed and the circulation through the placenta stopped before the child can respire. But the configuration so admirably adapted for the safe delivery of the child is incompatible with man carrying his body erect. To possess that power, which belongs exclusively to him, it is necessary that the pelvis should be expanded, to afford a secure basis for the trunk, and the lower extremities elongated and strong, to give freedom and power of motion to the limbs. Such a change, however, in the relative proportions of the figure cannot be effected except by the growth of the pelvis and of the lower extremities proceeding with greater activity than that of the head, chest, and upper extremities. And this, observation shows, is the actual course by which the several divisions attain their mature form. Hence it follows, that if, by the prevalence of a diseased action capable of retarding the growth, the natural process is interrupted, there will not only be a deficiency of size in all the body, but the change in the relative proportions of the figure which occurs simultaneously will be interfered with; and the patient, when arrived at maturity, will retain, in a greater or less degree, according to the severity or long conti-

nuance of the disease, marks of the configuration of the child.

Now, as rickets is a complaint of the character referred to (for it is known to be attended with marasmus, or general wasting of the body, and it is owing to the bones being imperfectly supplied with the hardening material which gives them firmness, that they become bent under the incumbent weight, and distortion ensues), we can understand how it should not only prevent the body attaining its full size, but give rise at the same time to that disproportion of the figure which has been described.*

The converse of this condition is observed in the figures of persons whose growth, instead of having been retarded, has been more active than common; as in men of large stature. Since the lower extremities increase at a more rapid rate than the parts above, it follows that the former become of inordinate length compared with the latter. Hence it is

* When I formerly solicited attention to these views, it was principally to point out their importance in connection with the dimensions of the pelvis in child-bearing women, deformed from rickets. It was my object to show, that as in the progress of growth this circle of bones undergoes an increase of its size more extensive in proportion to its original dimensions than any other part of the skeleton, (and the difference is greater in the female than in the male,) the interruption of the growth caused by rickets, gives rise to a correspondingly great diminution in its bulk, compared with the rest of the skeleton. To ascertain the average amount of this deficiency, and thus judge of the share which the consequent smallness of the pelvis has in

found, that the giant or tall person, distinguished by his long legs and comparatively small body, deviates from the standard proportions as greatly as the ricketty individual, with his large body and short legs.

Of the Proportions of the Head in persons deformed from Rickets.

In entering upon this subject, I may refer again to the opportunities which the streets of this metropolis afford to the observer, of studying the effects produced upon the growth of the various parts of the body by rickets. Since the time of Glisson, England has had the bad reputation of abounding in individuals deformed from that disorder: so that our brethren on the continent have applied to rickets the name of the "English disease." It may certainly be acknowledged, that the close alleys, the ill-ventilated and badly drained courts, of the

impeding the passage of the child in parturition, and causing difficult labour, I took the measurements of twenty-nine deformed pelves from patients of the female sex, and compared them with those of the natural female pelvis. The result was, that the deformed pelves fell short of their normal dimensions, by nearly one quarter of their proper size. So that in women distorted from rickets, two distinct causes give rise to difficult labour. First, the distorted condition of the pelvis, consequent on the softened state of the bones and the compression to which they have been subjected: secondly, the general smallness of the bones, depending on the pelvis having been originally, at childhood, of remarkably diminutive size, and on its growth having been interrupted by the attack of rickets.

densely populous parts of the city of London, are nurseries where a vast number of distorted and stunted persons are constantly reared; and the disease is not uncommon in the richer classes of the community.

When we observe the shape of the head in such deformed persons, it will be perceived, that one general character belongs to them:—*That whilst the cranium appears unusually large and capacious, the face is remarkably small.*

It is to this want of proportion between the size of the face and of the cranium, that I chiefly desire to direct attention. Owing to the original diversity in the shape, height and features of people generally, the disproportion may be more marked in some than in others; but after extensive observation, I feel confident in stating that it is a never-failing effect of rickets. I would add, that there is a numerous class of persons, who, although not actually distorted, or ricketty, in the common acceptation of the term, present the appearance of having suffered from continued bad health during childhood, and to have been checked in their growth from that cause: they are diminutive in height, and have more or less distinctly marked the relative proportions of the figure characteristic of those deformed from rickets; in such individuals, the cranium is generally disproportionably large, contrasted with the face.

For some time past, I have taken every opportunity of putting the above observation to the test

of measurement, by measuring the size of the cranium, and of the face, respectively, in the skulls of ricketty skeletons; and then comparing them with corresponding measurements of the natural skull. I have likewise followed the same course with as many deformed persons as I could persuade to allow me to measure their heads for a similar purpose. The details of the different measurements will be found in the table appended to this paper.

By referring to the table, it will be seen that the size of the whole head in ricketty persons is below the standard dimensions. But the degree of that deficiency is much more considerable in the face, than in the cranium. On looking to the part of the table which shows the average dimensions of each division, in all the specimens together, it will be found that, while the cranium falls short of the normal size only by $\frac{1}{21}$th part, the face falls short by as much as $\frac{1}{5}$th. Or, as another means of exhibiting the difference, if the combined measurements of the face, in all the specimens, be taken as the unit with which to compare the similar measurements of the cranium, the size of the cranium in the ricketty skulls will be found to be to that of the face as $7\frac{1}{13}$th to 1; while in the natural skull the ratio is as 6 to 1.

There being no doubt, therefore, that the disproportion here pointed out between the dimensions of the cranium and of the face in persons deformed from rickets, is a general character in such individuals,

it remains to be explained in what manner it is produced. I will endeavour to show that the appearance may be accounted for by applying to the head the same principle which was made use of in explaining the peculiar configuration of the body, treated of in my former paper.*

* The peculiar form of the head described in the text did not escape the observation of Sir Charles Bell, or Mr. John Shaw. In the third edition of his work on "Expression," now preparing for publication, when treating of the various characters observed in the skull, Sir Charles makes some comments on the antique bust of Esop, preserved in one of the galleries of Rome. After pointing out the remarkable appearance given to the head, by the face being made small and contracted, and the forehead large and overhanging, he observes that these characters are consistent with what the rest of the figure shows, and history records,—that the fabulist was deformed. He assumes that his deformity arose from rickets; and as in that disease the bones generally are in a soft state, and the jawbones must have been in the same condition, he concludes that the powerful muscles of mastication inserted into the lower jaw-bone must have had the effect, by their constant contraction, of compressing both maxillæ, so as to diminish the size of the face. The explanation proposed by my brother did not differ widely from that just noticed. When he wrote on distortion of the spine, it was the common practice, in the treatment of lateral curvature, to encumber the young patient with the weighty machine, now banished from the armoury of such practitioners, called "Cheshire's" instrument. One essential part of that apparatus was a chin-strap suspended from a rod which arched over the head, and sustained the trunk by coming under the chin. Mr. Shaw thought that the effect of the constant pressure of this strap upon the lower jaw was to impair its growth, and thus give a contracted appearance to the face. But neither of these modes of accounting for the peculiar form of the head, if properly scrutinized, will be found satisfactory.

Of the change which occurs in the relative dimensions of the Cranium and Face during the growth of the Head.

It is well known to physiologists that, independently of the increase which takes place in the general dimensions of the head as it grows between infancy and adolescence, a change is simultaneously produced in the proportions of the two distinct parts into which it is commonly divided—the cranium and the face. The head of the child is remarkable for the large size of the cranium, and the comparative smallness of the face. But as the growth proceeds, this conformation undergoes a gradual change: the face acquires each year a progressively larger size compared with the cranium, until at adolescence, it is of great bulk and capacity, while the cranium is relatively small, and the proportions thus become nearly the reverse of those at infancy.

This change in the proportions has relation to the difference in the development of the important organs to which each division of the head is peculiarly subservient. The chief use of the cranium is to contain and give protection to the brain; and the brain is remarkable, among all the organs of the body, for the advanced condition of its development at an early period of life, and for the little progress which it makes in adding to its size, when the growth is still proceeding actively in the rest of the frame. From the tables recently

published by Professor Reid,* it appears that the brain weighs nearly as much at about five or six years of age, as it does at adolescence. This circumstance may account for the bones of the cranium undergoing such a trifling change in their dimensions after the first years of childhood. With regard to the bones of the face, their bulk is made up chiefly of the two maxillary bones, and of those processes, which, by projecting from the adjoining parts of the skull, afford extensive origin to the powerful muscles inserted into the lower jaw. The main, if not exclusive use of both jaw-bones, is to give lodgment to the teeth; and their growth, therefore, bears relation to these parts. As the teeth are developed at a slow rate compared with other structures of the body, and it is not till adolescence that the permanent set have acquired the long and powerful fangs by which they are firmly socketed in the jaws, it follows that the maxillary bones continue adding to their bulk, in correspondence with the increasing size and number of the teeth, till that period. Then, as the muscles which operate on the lower jaw become larger and more powerful in proportion as the jaws and teeth increase in magnitude, the processes of bone from which they arise, and which contribute to make up the bulk of the face, get proportionately

* See the London and Edinburgh Medical and Surgical Journal, for April 1843.

larger and more prominent at the same time. Hence the whole face goes on increasing in size long after the cranium has ceased growing; and a change in the relative dimensions of the two parts is the necessary result.

To show numerically the difference between the rate of growth in the cranium and the face, after the few first years of childhood, I took the measurements of each of these two divisions, first in the skull of a child four years old, and then in the skull of an adult, and compared them together. I found that, whereas the cranium had increased in size only to the extent of $\frac{1}{8}$th of its full dimensions, the face had increased as much as $\frac{1}{3}$rd. Again, on taking the face as the unit of comparison, I found the size of the cranium, at four years of age, to be to that of the face as 8 to 1, while at adolescence it was only as 6 to 1.

It thus appears that there is an analogy between the mode of growth of the head, and that of the entire body: that as in the body, the lower division, consisting of the pelvis and inferior extremities, is developed at a quicker rate than the upper division, consisting of the head, trunk and superior extremities, so in the head, the face is developed at a more active rate than the cranium.

Rickets, by interrupting the growth, prevents the Head acquiring its proper adult form.

It may now be understood how a disease which

arrests the growth, as rickets has been proved to do, will produce the same effects upon the figure of the head, as it has been shown to give rise to in the body generally. Besides causing a general smallness of the head, it will occasion a disproportion between the parts of which it consists. As the two divisions, the face and the cranium, grow respectively at different rates of activity, it must follow that when the whole process is interrupted for a certain time, the stoppage will have a more decided effect upon the one than upon the other—upon the division which grows at a rapid rate, than upon that which grows at a more moderate rate. Hence as it is the face which is developed in the most active manner, and the cranium which increases at a slow rate, we may expect to find that there will be a very considerable defect in the size of the face, and only a trifling defect in that of the cranium. In other words, in persons whose growth has been interrupted by rickets, the face will appear extraordinarily diminutive, while the cranium will retain about its natural dimensions. Or the same thing may be expressed otherwise: as during the natural course of the growth, a change is gradually effected in the relative dimensions of the head, so that the face, which was originally small compared with the cranium, becomes eventually much larger in reference to the same part, it follows that when the process is arrested, the progress of the change in the proportions is also interrupted, and the head therefore retains at adolescence the characters,

more or less distinctly marked, which distinguish it at infancy. Now this corresponds with the description which has been given of the actual condition of the head in ricketty persons. The table shows that, taking the dimensions of the face as the unit of comparison, the relative size of the cranium to that of the face in the child, is as 8 to 1 : in the adult of normal proportions as 6 to 1 ; while in the adult whose growth has been interrupted by rickets, it is as $7\frac{1}{13}$th to 1 ; that is, the ratio in such individuals is intermediate between what it is in the child and the adult.

It may accordingly be perceived, that the effect produced by rickets on the form of the head resembles exactly that which was shown, in my former paper, to be produced from the same cause, on the configuration of the body.

Of the proportions of the Head in persons above the standard size.

When persons grow above the standard height it of course implies that the process of growth must have been carried on in these individuals with preternatural activity. It is therefore interesting to observe the effect which that acceleration produces on the relative dimensions of the cranium and the face ; and to ascertain whether it be the reverse of what is produced when the growth is retarded by rickets.

As, of the two divisions of the head, the face

grows at a quicker rate than the cranium, it is natural to expect, that when the process generally has an increased impulse given to it, so that both parts advance, each in its own ratio, more rapidly than usual, the face will acquire a much greater additional size than the cranium. This corresponds with what we observed in the body generally, where the two divisions growing at unequal rates, it was found that when the growth was accelerated, the lower extremities which grow most quickly, became disproportionately large and elongated compared with the head, trunk and upper extremities, which grow at the slowest rate. Accordingly, in the heads of tall, overgrown persons, we may look for the face being of extraordinary large size, and the cranium of relatively small dimensions. Now that is just the character of the proportions in such persons: and those who reside in London have excellent opportunities of verifying the observation, by attending to the relative size of the two divisions of the head in those fine, gigantic men, who belong to the household troops. It must have been often noticed that the features and countenances of these men are peculiarly large and strongly marked, while the cranium does not exceed the ordinary size: that although they have broad cheeks, large jaws, and overhanging eyebrows, yet the foraging caps which they wear in their undress, do not appear larger than those which would fit men of common

height.* To confirm my statement more accurately, I took the measurements of the cranium, and of the face, in the skull of the remarkable skeleton of the giant, preserved in the Museum of the College of Surgeons, the height of which is within three inches of eight feet; and I then compared them with those of the skull of standard size. I found that in the circumference of the cranium, immediately above the supraciliary ridges, the difference in favour of the gigantic skull was not more than $\frac{1}{8}$th of the whole measurement, while in the face, it was as much as $\frac{1}{3}$rd. Again, on taking the measurements of the face again, as the unit of comparison—while in the skull of standard size the dimensions of the cranium, as we have already seen, are to those of the face as 6 to 1, in the skull of the giant they are only as 5 to 1.

Accordingly the extremes in the disproportions of the adult skull, depending on the causes which have been explained, are as follows:—In the person stunted from rickets, the cranium is to the face as $7\frac{1}{13}$ to 1; in the gigantic person as 5 to 1. The former, in a partial measure, exhibits the conformation of head characteristic of the infant: the latter, that proper to the adult, but in an exaggerated or caricatured manner.

* An army clothier who furnishes the caps for one of the regiments of Horse Guards, has informed me that the size provided to these troops, is as nearly as possible the same as in those supplied to the regiments of the line, for men of common stature.

The size of the Orbits does not vary with the varying dimensions of the Face.

A curious fact concerning the capacity of the orbits in skulls of different sizes, came under my observation when pursuing the above measurements.

Having proved in the manner just related, that owing to the inequality in the rate of growth in the two divisions of the head, considerable variations take place in the proportions of these parts according to the activity of the process, I was desirous of ascertaining whether the orbits participate in the same changes. As these cavities are more particularly parts of the face, it was interesting to observe whether they were unusually enlarged in those skulls where the face generally is large, or diminished where the face is small; or if, on the contrary, they preserved a uniformity in their size, corresponding to the uniform dimensions of the eye-ball and its appendages lodged within them.

With the view of determining this point, I kept a record of the dimensions of the vertical and horizontal diameters of the outer circumference of the orbits, in all the different skulls which I examined. The list, therefore, exhibits the sizes of the orbits in skulls of all different dimensions, from that wherein the face is of the smallest size, as in the skulls affected with rickets, to that where it has attained the largest size, as in the skull of the giant.

If this list be examined, by running the eye along the line of figures which shows the measurements of the orbits, it will be perceived, that there is scarcely an appreciable difference between the dimensions of these parts in any of the skulls. Whether we take the ricketty skulls, those of standard size, or the skull of the giant, the diameters of the orbits measure the same in all. As they are not below the standard dimensions in the ricketty specimens, so they are not above them in the giant. The question therefore arises, how is this apparently anomalous fact to be accounted for?

It may be explained by observing the varying sizes of two chambers in the bones of the face, situated in the immediate proximity of the orbits—the frontal and maxillary sinuses. These cells are placed in such a manner in reference to each of the sockets, that the frontal sinus lies directly above, while the maxillary sinus lies directly below the cavity of the orbit: one of the walls or boundaries of the former forming the principal part of the roof, and one of the walls of the latter, the floor of each orbit. From this anatomical relation, it follows, that a correspondence is preserved between the size of the sockets and that of the two sinuses: for it is obvious that if the sinuses increase in their capacity, they will encroach in a proportionate degree upon the cavities of the orbits above and below, and so diminish the relative size of these parts; and if they be of diminutive capacity, they will encroach the

less upon the orbits, and therefore allow them to be of comparatively greater size.

Now I have satisfied myself by carefully examining the size of the frontal and maxillary sinuses in skulls of different dimensions, that where the face generally is largely developed, these cells are expanded to a great degree, and constitute the chief part of the bulk around the orbits: whereas in those skulls where the face generally is diminutive, they are correspondingly small. And that agrees with what we might expect from knowing the manner in which these cells are developed. Neither the frontal nor maxillary sinus exists in the skull of the infant: they are only to be discerned when the bones of the face have advanced considerably in their growth; and it is not till the skull has reached maturity, that they attain their full size. It is therefore natural to suppose that when the process of growth is unusually active these cells should become of large size; and when it is retarded, they should be of small dimensions.

Accordingly we may conclude that, whatever other uses the frontal and maxillary sinuses may serve, they are placed in the peculiar positions which they occupy in reference to the orbits, for a special object—that by becoming enlarged to different degrees in correspondence with the varying rate of growth in different persons, they may regulate the size of the orbital cavities; so that whether the face be larger or smaller than the standard size, a uniform relation may be always preserved between

the capacity of the orbits and the size of their contents.

Further remarks on the general form of the Head, in Rickets.

Having noticed the effects produced upon the orbits by the difference in the development of the frontal and maxillary sinuses, I may advert briefly to certain peculiarities in the shape of the forehead, which are to be ascribed to the same cause.

It must have struck all those who have observed the form of the front part of the head as it is generally presented in ricketty persons, that it is characterised by being remarkably square and full. To such a degree does the prominence here referred to commonly amount, that the forehead projects beyond the level of the face, and the facial line, drawn from the top of the head downwards, inclines inwards, instead of advancing forwards, as in the skull of normal shape. I may add that this broad and projecting condition of the forehead is often looked upon with satisfaction, as indicating a corresponding enlargement of the brain at that region; and the individual is therefore considered to have a finely developed head.

It must also have been noticed, that in persons of large stature, the front part of the cranium, instead of being unusually prominent, generally shelves backwards, so as to produce a low forehead; and a vulgar

idea also prevails that there is a positive smallness of this part of the skull, as contrasted with the normal dimensions.

But this difference in the appearance of the head, in persons of short and large stature, does not depend on an actual difference in the capacity of the frontal region of the cranium, but on the different size of the frontal and maxillary sinuses which adjoin that part. Owing to the relative situation of these cells to the forehead, the front part of the head appears either largely developed, or the contrary, according as the sinuses are expanded to a great size, or the reverse. For, as the frontal cells occupy the lower boundary of the forehead, and in the natural condition of the head, cause that slight fulness above the orbits, called the supraciliary ridges, on which the eyebrows rest, it follows that if they are of large size, they will project beyond the level of the superior part of the forehead, and make it recede to a proportionate degree; and that if they be small, there will be a deficiency in the part below, and a corresponding prominence above. Again, as the cheek bones and the zygomatic processes rest on the summits of the maxillary sinuses, and project to a greater or less degree in proportion as these cells are large or small, so that the upper and lateral parts of the face, just below the temporal regions of the cranium, are either protuberant or narrow, according as the maxillary sinuses are expanded much, or the reverse,—it follows, that the lateral parts of

the frontal bone, will appear remarkably full, or imperfectly developed, according as the sinuses are of large or small dimensions.

Hence, although children labouring under the effects of rickets are generally distinguished for precocity in their mental faculties, and the same acuteness of mind, which thus results primarily from disease, when judiciously cherished by education, is frequently found to be retained by the adult, so that persons with this kind of deformity are often noted for their superior intellectual attainments,—it cannot be said that the condition of mind has any connection with the peculiar breadth and prominence of the frontal region which has been described : because that appearance does not indicate an enlargement of the cranium, but only a comparative smallness of the face.

On the effects produced by the interruption of the growth from Rickets, upon dentition.

The teeth, it is well known, do not grow as integral parts of the skull. On the contrary, they differ from bone both in constitution and structure, and have a perfectly distinct mode of formation. While the maxillary bones progressively increase in dimensions by a process of growth common to the rest of the skeleton, a succession of teeth, each separately developed in the interior of the jaw-bones, and adapted in size and number to their capacity for containing them, is in the constant course of being

evolved. When the jaw-bones become too large for the teeth first formed, another set, accommodated to the adult size of the bones gradually replaces the original series.

This short account of a process with which every one is familiar, is enough to show what an exact relation must exist, during the whole period of growth, between the increasing size of the maxillary bones, and the formation of the teeth. To enable each distinct tooth to appear above the gums, and fall into its appropriate place in the ranges of the teeth of both jaws, just at the time appointed, it is obvious that the bones and the teeth must accord in their growth with the nicest accuracy; and if one of the parts, as the bones, be interrupted in its growth, even if it be for a short period, there is danger of all the subsequent stages of the process being materially deranged.

After what has been stated in the preceding part of this paper regarding the effects produced by rickets upon the growth of the skull, no doubt can be entertained that the maxillary bones are retarded in their development, in children affected with that disorder, in common with the rest of the face. And as it is at the period of life when the most important parts of the process of dentition are in course of being carried on, that the disease commonly prevails in an active state, it is evident that the stoppage of the growth of the jaw-bones at that time must have a decidedly injurious influence on the development of the teeth.

It would be interesting, in connection with the present inquiry, to determine how far the teeth participate in a direct manner in those changes which rickets produces on the osseous system generally. That the parts of the teeth which are completely formed before the disease begins, should undergo any alteration of structure in consequence of the disease, is extremely doubtful: but it is not improbable that the portions still in progress of formation while the disease continues, may be affected by the morbid influence. As far as I can ascertain, however, this question has not hitherto been properly investigated: at least, since the many interesting discoveries concerning the minute structure of the teeth, recently made by microscopical observers, have had the effect of introducing so much more certainty than existed before into observations on this subject.

But putting that view aside for the present, there are two principal circumstances—the one connected with the growth of the teeth, the other with that of the maxillary bones—to which it is necessary to attend before we can comprehend fully the effects to which rickets is likely to give rise upon dentition.

In regard to the first point, namely, the growth of the teeth: it is to be observed that there is an essential difference between the very first steps of that process and the growth of the jaws. This contrast is so great, especially with reference to the crowns, which constitute the chief bulk of each tooth respectively, that whereas the maxillary bones, in

common with the rest of the skeleton, increase in size slowly and progressively, these parts of the teeth are as large, and occupy as much room in the jaws at the outset of their formation, as they are capable of doing at the termination. This fact is explained by the teeth being formed in the substance called the pulp, and by their growth proceeding from without inwards, so that the external layers on which the ultimate size and shape of each depend, is deposited first, instead of last. Now, although this description applies correctly to the formation of the crowns only, for the fangs are developed later and in a more progressive manner, it may be perceived how important the fact is for throwing light upon the mode in which rickets, by arresting the growth of the jaws, must affect the development and successive rising of the teeth. As it is found that while the jaws are only commencing their growth, and are still of diminutive size, the crowns of a certain number of the teeth not yet emerged above the gums, are of as great bulk as they are destined afterwards to be (having been formed of these dimensions with the prospective design of being adapted to the mature size of the jaws), it is obvious that when the maxillary bones are interrupted in their growth, and are prevented reaching their full size, the teeth will be too large for them—there will be a want of correspondence between the size of the teeth, and that of the part of the jaw-bones allotted for containing them. Hence the effect will be, that the teeth will be wedged closely

together within the jaws, that they will make their way to the surface with pain and difficulty, and assume an irregular appearance when they have risen above the gums.

The second point to be noticed relates to an important observation made by Mr. John Hunter, concerning the growth of those portions of the jaw-bones in which the teeth are placed.

In examining the mode in which the permanent teeth succeed the deciduous set, Hunter was led to conclude that the posterior division of that portion of each maxillary bone which is destined for the reception of the teeth, grows with greater activity than the anterior; that while the anterior division remains, between childhood and adolescence, almost stationary in size, the posterior division acquires a large accession to its dimensions. He was brought to form that opinion from the following course of observation and reasoning. Upon looking to those teeth alone, belonging to the permanent set, which take the places of the entire deciduous set, that is, taking the twenty permanent teeth of both jaws, extending backwards in each jaw to the second bicuspids (these being the permanent teeth which succeed the last of the deciduous set) and the twenty deciduous teeth, and comparing their collective size with each other, he observed that there was only a trifling difference between them. He inferred, therefore, that the parts of the jaws which first held the deciduous teeth, cannot have enlarged

much during the period when they were shedding and giving place to the corresponding number of permanent teeth, but must have continued about the same dimensions throughout. But as room must be formed in the jaws of the adult, behind the place occupied in the child by the last molar teeth, that is, in a part where no teeth existed before, for the lodgment of the large permanent molar teeth; and as that can only be obtained by a proportionate addition being made to the jaw-bones at that part, it follows, that the growth must proceed with great activity at the posterior division of the jaws during the rising of the molar teeth. The degree of that activity of growth, compared with the rate in the anterior division, may be estimated by observing that the size of the part of the jaws which contains the molar teeth, is about equal to that which contains all the others situated anteriorly.

It is obvious, therefore, that if, while the evolution of the teeth is still going on, the growth be interrupted for a time, the effect will be greatest upon those portions of the jaw-bones which grow at the quickest rate; that is, upon the posterior portions containing the permanent molar teeth, than upon the anterior portions. That such is the case, at least as regards the superior maxillary bones, we have already had evidence of an indirect kind to prove. It was shown, when treating of the effect produced on the size of the orbits by the frontal and maxillary sinuses becoming developed to a greater or less degree in

proportion to the activity of the growth, that these sinuses were remarkably diminutive in persons retarded in their growth by rickets. Now as the maxillary sinuses are in anatomical relation at their inferior parts with the divisions of the jaw-bones superadded to give lodgment to the permanent molar teeth (for the alveolar processes of these teeth together form the floors of each of the sinuses), it follows that when the sinuses are generally small, the parts in which the molar teeth are contained must likewise be small. Hence, the obvious effect will be, a want of due proportion between the size of the molar teeth and that of the portions of the jaws intended to lodge them—the teeth will be too large for the jaws, in these parts.

The above views seem to me not undeserving the attention of those members of the profession, who, from the particular department of practice which they follow, have more ample opportunities than others of observing the derangements of health commonly supposed to depend on a disturbed state of the process of dentition. It is also to be conceived that they will be interesting, in a peculiar manner, to the dentist.

Since they occurred to me, I have not had sufficiently extensive means of judging how far they may be applied with advantage to the elucidation of disease, so as to express any confident opinion on that subject. But I will offer the following remark as a suggestion to those who may intend prosecuting

the inquiry. In observing the diseases of children which take place at the period of teething, we are perhaps too much in the habit of referring the derangement of health to the condition of the teeth; as if the difficulty and pain in protruding the teeth above the gums were the first and original cause of the disorder. It may perhaps be found, by pursuing our observations with more care, that the constitutional irritation proceeding from this cause is a secondary, rather than a primary object of our attention. It is not improbable, in short, that the disturbance in the process of dentition has itself resulted from previous constitutional derangement. It may happen that, owing to a bad state of the health analogous to rickets, and independent of the state of the teeth, an interruption may have been produced in the growth of the maxillary bones; and from that has arisen a want of correspondence between the size of the teeth and of the bones, sufficient to account for the derangement of the teething.

Before quitting this subject, I beg to refer to the valuable researches of my colleague Dr. Ashburner, into the question of the influence of protracted and difficult dentition, in giving rise to various obscure forms of disease in persons more advanced in life than children. It appears to me that the views brought forward in the present paper, may throw considerable light on the causes of the want of relation between the size of the jaws and of the teeth,

to which that gentleman attaches so much importance, in explaining the derangements to which he refers.*

In conclusion, I may here give a short description of a remarkable condition of the teeth and jaws, which I have had the opportunity of observing since beginning this paper, in a patient greatly distorted from rickets, who is at present in the Middlesex Hospital. I have observed in numerous persons deformed from that disease, great crowding, accompanied with much displacement and irregularity, of the teeth in both jaws, apparently produced from want of proportion between the size of the bones and that of the teeth; but in none have the effects been so distressing as in the case to which I refer. The patient is a girl, seventeen years of age, who was admitted into the hospital under the care of my colleague Mr. Arnott, for fracture of the left thigh bone. Her whole body is distorted in the manner usually seen in those who have had rickets in early childhood, but to an aggravated degree such as we seldom witness. On looking to the curved and twisted state of the legs, it is only surprising that she should have been able to walk before she met with the fracture. In regard to the appearance of the head, it is particularly remarked that it has the proportions of the child about six or eight years of age, instead of those of a person of her time of life;

* On Dentition, and some coincident Disorders. By John Ashburner, M.D. 1834.

and so much does this peculiarity in the proportions of her head deceive those who are asked to guess her age, that she is invariably supposed, at first, to be only about eight years old. Both jaws are remarkably small; and the teeth present several irregularities. The first thing which attracts our notice, is the disproportionately large size of the crowns of the front teeth when compared with the smallness of the jaw-bones. The next, is the great number of teeth which are wanting, without there being sufficient room to receive additional ones. Although the patient has arrived at that period of life when she ought properly to have the full complement of permanent teeth, she has only fourteen teeth altogether in both jaws; and the vacant spaces which mark where the teeth that have dropped out were formerly placed, are all so narrow that it would be impossible for them to contain a sixth part of the teeth that are lost. Another circumstance marks in a striking manner, by the distressing effects to which it gives rise, the want of correspondence which must have existed, during the growth, between the development of the teeth and of the jaws: although the crowns of most of the teeth, as already mentioned, are large enough to be adapted for jaws of full size, the fangs are extremely small, and the sockets correspondingly shallow and imperfect; the consequence of which is that these teeth are all quite loose; so that they can be easily shaken to and fro with the fingers, and it is with great pain and difficulty that she chews her food.

TABLE showing the relative proportions of the Cranium and Face in different periods and conditions of the growth.

	Giant's skull, height 7ft. 9in.	Average of six adult skulls.	Average of two skulls at birth.	Skull, five to six years of age.	Rickets. Adult.	Rickets. Adult.	Rickets. Adult.	Rickets. Adult.	Average of the ricketty skulls.	Average of heads of seven ricketty persons	Average of of heads of three adults. Normal.
CRANIUM :—											
Circumf. of skull above supracil ridges.	$22\frac{3}{8}$	$21\frac{1}{4}$	$13\frac{1}{8}$	$18\frac{3}{4}$	$19\frac{6}{8}$	21	20	$20\frac{1}{8}$	$20\frac{1}{4}$	$21\frac{1}{4}$	$22\frac{1}{2}$
FACE :—											
From naso-frontal suture to chin.	6	5	$1\frac{3}{4}$	$3\frac{1}{4}$	$3\frac{5}{8}$	$3\frac{1}{2}$	$3\frac{3}{4}$			$4\frac{1}{19}$	5
Meatus auditor. ext. to symph of up. jaw.	$5\frac{3}{8}$	$4\frac{1}{2}$	$2\frac{1}{3}$	$3\frac{1}{2}$	$3\frac{7}{8}$	$3\frac{3}{4}$	4	$3\frac{3}{4}$		$4\frac{5}{8}$	$5\frac{1}{2}$
One os malæ to the other.	$5\frac{1}{2}$	$4\frac{5}{6}$	$1\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{8}$	4	$3\frac{3}{4}$	$4\frac{1}{8}$		$4\frac{1}{4}$	$4\frac{3}{4}$
Front pr. of up jaw to edge of alveol.	$3\frac{1}{8}$	$2\frac{1}{2}$	$1\frac{1}{3}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$			
Poster. molar tooth of one side to other.		$2\frac{1}{2}$		$1\frac{7}{8}$	$1\frac{7}{8}$		$1\frac{5}{8}$	$1\frac{3}{4}$			
Angle of low jaw to symphysis.	$5\frac{1}{2}$	$4\frac{1}{2\frac{1}{4}}$	$1\frac{1}{2}$	$2\frac{5}{8}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{1}{4}$			4	$5\frac{1}{4}$
Articul. surface to angle of jaw.	$3\frac{3}{4}$	$2\frac{2}{3}$	$\frac{7}{8}$	$1\frac{1}{2}$	$2\frac{1}{8}$	$2\frac{1}{8}$	2				
One angle of jaw to other.	$4\frac{5}{8}$	$3\frac{1}{2}$	$1\frac{7}{8}$	3	$3\frac{3}{8}$	$3\frac{1}{8}$	3			$2\frac{1}{2\frac{1}{4}}$	3
Chin to edge of alveolar proc.	$1\frac{3}{4}$	$1\frac{1}{4}$		$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1				
Average of the dif. meas. of face.	$4\frac{5}{8}$	$3\frac{7}{17}$	$1\frac{3}{5}$	$2\frac{1}{2}$	$2\frac{7}{9}$	$2\frac{7}{8}$	$2\frac{7}{9}$	$2\frac{7}{8}$	$2\frac{7}{8}$	$3\frac{4}{5}$	$4\frac{7}{10}$
Proportion of cranium to face as unit.	$4\frac{8}{9}$	6	$8\frac{1}{5}$	$7\frac{1}{2}$	$6\frac{10}{11}$	$7\frac{1}{3}$	$7\frac{1}{5}$	7	$7\frac{1}{2\frac{1}{3}}$	$5\frac{2}{3}$	$4\frac{3}{4}$
ORBIT :											
Longitud. diameter of orbit.	$1\frac{3}{8}$	$1\frac{3}{7}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$		$1\frac{1}{4}$	$1\frac{1}{2}$			
Transverse diameter of orbit											